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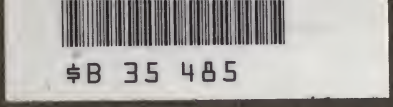

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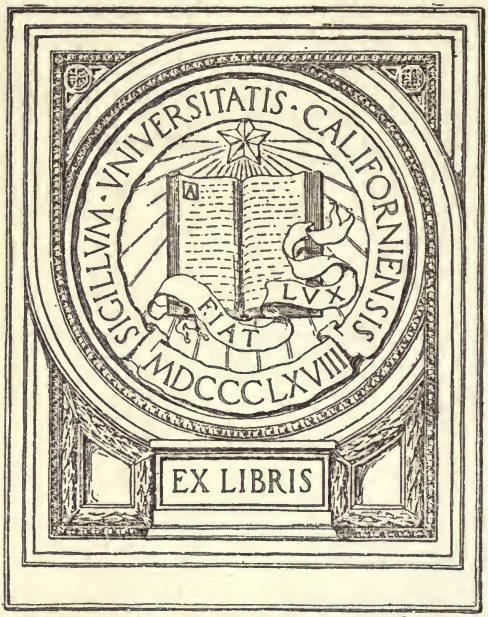
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# HISTORICAL ECLIPSES

BEING

## THE HALLEY LECTURE

DELIVERED 17 MAY 1921

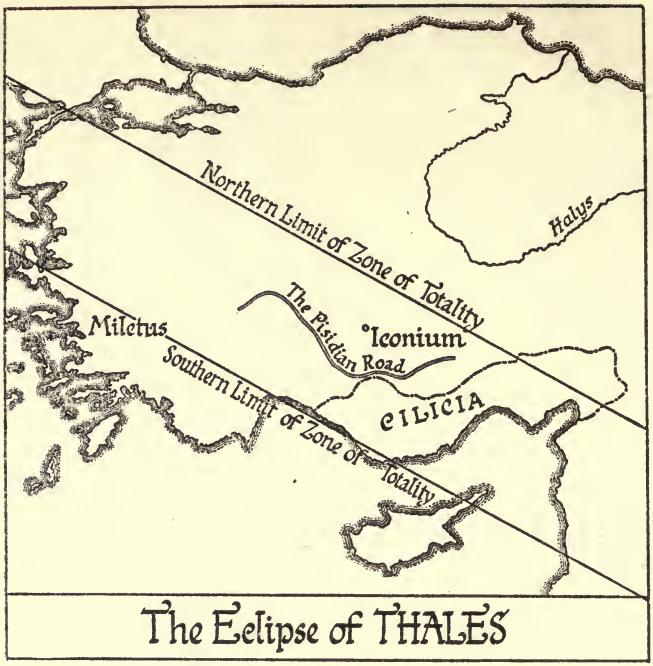
BY

JOHN KNIGHT FOTHERINGHAM
M.A., D.Litt.
*Assistant in the University Observatory, Oxford, sometime Fellow of Magdalen College, Oxford, and Reader in Ancient History in the University of London*

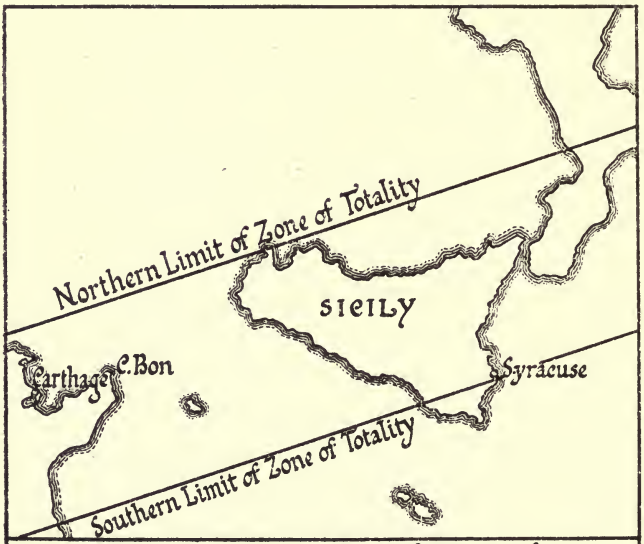
OXFORD
AT THE CLARENDON PRESS
1921

CALIFORNIA

# HISTORICAL ECLIPSES




The Eclipse of THALES




The Eclipse of AGATHOCLES

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# HISTORICAL ECLIPSES

PERHAPS the most important astronomical event of the year 1920 was the publication of Dr. Brown's *Tables of the Motion of the Moon*. It is a stupendous work. It consists of three solid volumes, containing 673 large quarto pages, including 14 pages of prefatory matter, and, bound in paper covers, weighs 9½ pounds. Dr. Brown spent altogether 29 years in improving the theory, computing the gravitational terms that enter into it, analysing the observations, preparing the tables, and seeing them through the press. Three Universities share the honour of this production, Cambridge which printed it, and Yale and Oxford which published it. The expense was met by appropriations from the income of the funds of the Winchester Observatory, U.S.A. A public lecture is not the occasion, and I am certainly not the person to appreciate the mathematical powers which the author has displayed, but I think it will generally be conceded that all that gravitational astronomy can perform has been brought to its perfection by Dr. Brown, and that the outstanding differences between Dr. Brown's places of the Moon and those obtained by observation are due to causes of which our gravitational theory does not take account. For the benefit of those who are not familiar with astronomical tables, I may explain that these tables do not give the position of the Moon, but merely facilitate the computation. With Hansen's tables, which have hitherto been used, it was estimated that a skilled computer could find one complete place of the Moon in a whole day's work. I hope

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it will be found that even with Dr. Brown's more elaborate tables the work can be done in two days. Happily the time taken in computing a number of places does not vary in proportion to the number of places computed. A comparison between the sizes of the tables of Burckhardt, Hansen, and Brown which have been successively used at the Nautical Almanac Office will show how much more numerous are the perturbations contained in this last set of tables than in its predecessors.

I referred a moment ago to the difference between the true position of the Moon and the position deduced from our most accurate tables. In the case of Dr. Brown's tables the principal cause of this discrepancy is that he has adopted too small a value for the secular or progressive acceleration of the Moon's motion. There are at least three causes which produce such an acceleration referred to our standard of time. Of these, the gravitational effect of the diminution in the eccentricity of the earth's orbit, discovered by Laplace, and the gravitational effect of the oblateness of the earth's figure, discovered by Stockwell, can be computed with exactitude, and Dr. Brown has made the proper computations. We know, however, that the total acceleration is greatly in excess of the values which can be computed from gravitational theory, and we know that part or all of this excess must be due to the action of the tides, more especially to the tides in shallow seas, more particularly the Behring Sea. This subject has been recently developed by Major Taylor and Dr. Jeffreys.[1] Unfortunately we are unable to determine from hydrographic observations or theory the amount of accelera-

[1] See in particular Dr. Jeffreys's paper, 'Tidal Friction in Shallow Seas', *Philosophical Transactions of the Royal Society*, A. 221 (1920), 239-64.

tion which is produced in this way, and we are thrown back upon astronomical observations for the determination of the total acceleration.

For this purpose modern observations are of little value, because the Moon's motion is subject to unexplained fluctuations, from which it is impossible to disentangle the effect of the acceleration. But this objection does not apply to ancient observations. The effect of an acceleration on the Moon's position is proportional to the square of the time during which the acceleration has been operating. But there is no reason to suppose that the fluctuations had a greater effect in ancient than in modern times. When, therefore, we deal with ancient observations, the fluctuations become negligible as compared with the acceleration, and, if the observations are good enough, a comparison of ancient with modern observations ought to give us the acceleration of the Moon. Dr. Brown, however, is of opinion that in tables designed for present-day use it is unnecessary to make any addition to that part of the acceleration which can be computed from gravitational theory, and has preferred to use the gravitational acceleration only, endeavouring to compensate the neglect of the rest of the acceleration by artificial changes in terms which can be determined by observation only. In my opinion the compensation is inadequate, and I venture to predict that the Moon will, subject to fluctuations, move further and further in advance of her computed position as time goes on.

The first suggestion of an acceleration of the Moon's motion was made by an alumnus of this University, Edmund Halley, afterwards Savilian Professor of Geometry, after whom this lecture is named, and that shall be my excuse for detaining you a little on the subject. Halley's announcement that he believed that

such an acceleration existed was made in the year 1695[1] in a paper published in the *Philosophical Transactions of the Royal Society*, entitled 'Some Account of the Ancient State of the City of Palmyra, with short Remarks upon the Inscriptions found there',[2] a paper which is at least a monument of its author's versatility. The paper neither measures nor demonstrates the acceleration, but merely indicates Bagdad, Aleppo, and Alexandria as the places in and near which the observations were made by which the Moon's motion was determined, and asks for observations of the phases of lunar eclipses at these places in order to determine their longitudes. He expressed a hope, destined never to be fulfilled, that he would one day demonstrate the existence of an acceleration.

It is curious that this suggestion of Halley's should have evoked no inquiry into the question till Dunthorne took the matter up fifty-four years later.[3] Dunthorne relied wholly on eclipses, and the interest attaching to the question of acceleration has led to many elaborate discussions of ancient and mediaeval eclipses from his time to the present day. Long before Dunthorne's day most of the eclipses mentioned in Greek and Latin writers had been satisfactorily identified and dated, but eclipses have retained their double interest, in which astronomical evidence is brought to the aid of the student of history, and historical evidence is brought to the aid of the student of astronomy. I have treated in papers published by the Royal Astronomical Society the astronomical results that can be derived from ancient eclipses.[4] In this lecture I shall assume the validity of

[1] Not in 1693 as frequently stated.
[2] *Phil. Trans.*, **19** (1695), 160–75.
[3] *Phil. Trans.*, **46** (1749), 162–72.
[4] Most recently in *Monthly Notices*, **81** (1920), 104–26, which summarizes the conclusions obtained in earlier papers.

my conclusions, and shall deal with the more general interest of individual eclipses.

We must remember that, because an eclipse of the Sun is total, if at all, on a part of the earth's surface only, we can calculate and draw on the map a band or zone of total eclipse, and, if an observer is known to have seen a total eclipse, we know that he must have been within that zone. In this way an eclipse of the Sun may give a student of history some information beyond a mere date.

It is only in ancient times that we find that individual eclipses have become embedded in literature and history. Later records of eclipses are more numerous, but have a less interesting setting, and are for the most part unimportant both for chronological and for astronomical purposes.

### *The Shû King Eclipse.*

We have early Babylonian documents giving the astrological interpretation of eclipses, but the earliest historical reference to an eclipse so far as I know is to be found in the Chinese work, entitled Shû King, or Book of Historical Documents. This work is a collection of public speeches and proclamations, with a few songs here and there, beginning in the reign of the emperor Yâo, whom the received chronology places in the twenty-fourth century before Christ, and closing with a speech by Duke Mû in B.C. 625. The documents, which were selected not for their historical value, but for the moral principles which they express, are sometimes accompanied by a brief explanatory statement of the circumstances in which they were issued, but the collection contains no continuous historical narrative and no attempt at chronology. Nor does any other early Chinese work supply this deficiency. The use of

the Shû King is rendered more difficult by the fact that all copies that could be discovered were destroyed by the energetic and utilitarian emperor Shi Hwang-ti, who in B.C. 212 ordered the destruction of all books except those devoted to the three useful branches of learning: agriculture, medicine, and divination. The destructive law was abrogated six years later and an incomplete copy of the Shû King, recovered from a wall in which it had been bricked up, provided an authentic text for the books which it contained. The book in which the eclipse is mentioned was not included in this copy and, although copies containing it were afterwards circulated, the prevailing opinion among both native and western scholars is that the additional books not contained in the first recovery are mere literary restorations made from quotations and references found in other works that had survived, with the aid of a preface or table of contents which would appear to have been made from the genuine text before the burning of the books and probably with the aid of other books or traditions that might bear on the subject.[1]

The preface to the book in which the eclipse is mentioned runs as follows:[2]

'Hsî and Ho, sunk in wine and excess, neglected the ordering of the seasons, and allowed the days to get into confusion. The prince of Yin went to punish them. Descriptive of this, there was made "The Punitive Expedition of Yin".'

Hsî and Ho, I must explain, were the hereditary

[1] Legge, *Chinese Classics*, iii (1865), part i, 34]–46], defends the authenticity of the whole of the extant text, but the opposite view is expressed by Chavannes, *Mémoires historiques de Se-ma Ts'ien*, i (1895), cxxii, cxxiii, who places the restoration in the fourth, and by M. Pelliot, 'Le *Chou King* en caractères anciens et le *Chang Chou Che Wen*', *Mémoires concernant l'Asie orientale* (*Inde, Asie centrale, Extrême-Orient*), ii (1916), 128 note, who places it in the third century of our era.

[2] Legge, *op. cit.*, iii, part i, p. 3.

astronomers, but it will be observed that the preface makes no mention of an eclipse.

Tso, a scholar of the fifth century before Christ, is regarded as the originator of a commentary on the Annals of the State of Lu from B.C. 722 to B.C. 464. This work, whether committed to writing or still transmitted orally at the time of the burning of the books, survived that catastrophe and appears to have been published in the first half of the second century before Christ.[1] It contains the following quotation from the lost 'Punitive Expedition of Yin'[2]:

'The Sun and Moon did not meet harmoniously in Fang. The blind [musicians] beat their drums; the inferior officers galloped and the common people ran about.'

To this is added the comment:

'That is said of the first day of this month;—it was in the fourth month of Hsiâ, which is called the first month of summer.'

The phrase 'The Sun and Moon did not meet harmoniously' is said to occur nowhere else in Chinese literature.[3] It is taken by all Chinese scholars to mean an eclipse of the Sun, as, for instance, by Tso in the context of the passage cited, and by the Annals of the Bamboo Books, a work of the early third century before Christ,[4] which escaped destruction, and in which the incident is recorded as follows:

'In his fifth year'—that is, in the fifth year of Chung K'ang—'in the autumn, in the ninth month, on the day *kăng siū* (forty-seventh of cycle), which was the first day

[1] Chavannes, *op. cit.*, i. cxlviii–cl.
[2] Legge, *op. cit.*, v (1872), part ii, p. 667.
[3] See Chalmers, 'Astronomy of the Ancient Chinese', in Legge, *Chinese Classics*, iii, part i, 101].
[4] The authenticity of this work has been disputed, but is defended by Legge, *op. cit.*, iii, part i, 105]–107], 176]–183], and by Chavannes, *op. cit.*, v (1905), 446–79.

of the month, there was an eclipse of the Sun, when he ordered the prince of Yin to lead the imperial forces to punish Hsî and Ho.'

It is not clear what this eclipse had to do with Hsî and Ho. The scholar who has restored the text uses such rhetorical language as to leave us in doubt what tradition, if any, he had received, but he seems to imply that they had either failed to predict or failed to observe the eclipse.[1]

There is a various reading as to the month in which the eclipse took place. The restored text, which is otherwise in close agreement with Tso's quotation, reads 'on the first day of the last month of autumn', a reading which is supported by the Annals of the Bamboo Books, while Tso in a reading supported by his context places the event on the first day of the first month of summer.

There is also doubt concerning the meaning of the word *Fang*. That name is now given to a small asterism including $\beta$, $\delta$, $\pi$, $\rho$ Scorpii and embracing about five degrees on the ecliptic, and the word has been taken in that sense by some native and most western scholars. The better opinion, also found both among native and western scholars, appears to be that *Fang* means 'the order of the constellations'. This view is supported by Chalmers[2] and by the authors of the most complete monograph on this eclipse, Schlegel and Kühnert.[3]

Even the emperor's name is not given in the preface or in Tso's quotation, but the Annals of the Bamboo Books, followed by a unanimous tradition, and supported

[1] The Chinese text of 'The Punitive Expedition of Yin', with an English translation and copious notes, will be found in Legge, *op. cit.*, iii, part i, pp. 162–71. A revised translation is given by the same scholar in *Sacred Books of the East*, iii (1879), 81–3.

[2] *Loc. cit.*

[3] 'Die Schu-King-Finsterniss', *Verhandelingen der Konin. Akad. van Wetenschappen, Letterkunde*, xix (1890), pp. 5, 6.

by the most cautious Chinese historian Sze-mâ-ch'ien,[1] place Yin's expedition in the reign of Chung K'ang. The Annals of the Bamboo Books, which preserve a system of chronology known to and sometimes used by Tso and Sze-mâ-ch'ien,[2] give an exact date, equivalent to our B.C. 1948, October 28. Unfortunately there was no eclipse that day, not even a new moon. Sze-mâ-ch'ien refused to trace Chinese chronology further back than B.C. 841.[3] Before that date he has no scheme of chronology beyond the bare names of emperors with their relation to each other. Tracing back the line, we may infer that Chung K'ang must have reigned within a century or two one side or other of B.C. 2000.

The Chinese astronomers of the T'ang dynasty (A.D. 618–906) endeavoured to fix the date of the eclipse by computation. They were divided between B.C. 2155 and B.C. 2128, and the received Chinese chronology, which is the work of Shâo K'ang-chieh, who lived in the eleventh century of our era, is based on the two assumptions that the first of these dates is correct, and that the eclipse fell in the fifth year of Chung K'ang. But, as Largeteau showed in 1840,[4] the eclipse of B.C. 2155 was not visible in China, a discovery which has given rise to the well-known rhyme:

> 'Here lie the bones of Ho and Hi,
> Whose fate though sad was risible,
> Being hanged because they could not spy
> The eclipse which was invisible.'

The chief difficulty in identifying the eclipse lies in the two uncertainties already mentioned, whether the first month of summer or last month of autumn is the

[1] Chavannes, *op. cit.*, i. 166.
[2] Chavannes, *op. cit.*, i. cxciii–cxcv; v. 476–8.
[3] Chavannes, *op. cit.*, iii (1898), 2.
[4] *Journal des Savants* (1840), 242. The error of the Chinese astronomers was, as Largeteau shows, due to their ignorance of secular acceleration.

correct date and whether the reference to *Fang* does or does not tie it down to the five days which the Sun takes to pass through the asterism now known by that name. This narrow interpretation of *Fang* agrees well with the reading 'last month of autumn', but cannot be reconciled with the reading 'first month of summer', and Schlegel and Kühnert have supposed that the reading 'last month of autumn' was substituted for the reading found in Tso's text in order to cohere with the falsely interpreted *Fang*. But as the reading which they reject is at least as old as the Annals of the Bamboo Books, I prefer to leave the question open.

Among modern investigators Oppolzer,[1] who reads 'last month of autumn' and takes *Fang* in the narrow sense, has proposed to identify the eclipse with that of B. C. 2137 October 22, while Schlegel and Kühnert, reading 'first month of summer', and confining their investigation to eclipses which attained a magnitude of 10 digits (i. e. in which five-sixths of the Sun's diameter were eclipsed) at the Chinese capital, conclude that the eclipse was either that of B. C. 2165 May 7, or that of B. C. 1905 May 12, and they express a preference for the earlier date. But it would appear that there are numerous Chinese observations of eclipses which were less than five-sixths total[2] and so the assumption on

[1] 'Über die Sonnenfinsterniss des Schu-king', *Monatsberichte der kön. preuss. Akad. der Wissenschaften zu Berlin*, 1880, 166–85.

[2] I have computed the three earliest dated Chinese eclipses, those of B.C. 776 September 6, B.C. 720 February 22, and B.C. 709 July 17, of which the first is recorded in the Book of Poetry and the other two in the Annals of Lu, the eclipse of B.C. 709 July 17 being described as total. Introducing my elements as corrections into Schram's 'Tafeln zur Berechnung der näheren Umstände der Sonnenfinsternisse', *Denkschriften der Kaiserlichen Akademie der Wissenschaften, math.-nat. Cl.*, li (1885), pp. 385–576, a useful set of tables where extreme accuracy is not required, I find that the first of these eclipses was not visible in the Chinese capital or anywhere in the royal domain, but would be visible as a small eclipse in northern China, the second attained a magnitude of 5·2 digits in K'euh Fow, the capital of Lu, while the third was total in that city.

which this investigation is limited fails. My opinion is that the evidence does not permit us to identify the eclipse.

No early authority states what the result of the prince of Yin's expedition against the astronomers was. The compilers of the Shû King were interested only in the sound moral sentiments expressed in his harangue to his troops, principles whose validity did not depend on the success or failure of his arms. Chû Hsî, who wrote the standard history of China, dated 1172 A. D., asserts that the astronomers surrendered and were executed,[1] and our western scholars have generally assumed that this view is correct. I venture to suggest a different restoration of the events. Before the accession of the emperor Chung K'ang the whole power was in the hands of Prince Î of Ch'iung.[2] Chung K'ang was probably, as Chû Hsî holds, intended by Î to be a mere puppet. There have been such emperors in China in our own day. We may further follow Chû Hsî in holding that the punishment of the astronomers was only a secondary motive with Chung K'ang when he gave a military command to the prince of Yin. His main object doubtless was to provide himself with an army that should be independent of Î. A glance at the dry chronology of the Bamboo Annals will suggest the course of the war. In Chung K'ang's fifth year, as we have seen, he appointed the prince of Yin to his command and sent him to punish Hsî and Ho. In his sixth year he appointed the prince of Kiun-wu to be

This is sufficient evidence that small solar eclipses were observed and recorded in China in the earliest age in which it is possible to identify them.

[1] *Histoire de la Chine*, translated by De Mailla, i (1777), 133.

[2] So the restored text of the Shû King, supported by a reference in Tso (Legge, *Chinese Classics*, v. ii. 424), and by the Annals of the Bamboo Books. The preface to the Shû King mentions the usurpation, but does not name the usurper.

leader among the princes and therefore to take precedence over Î. In his seventh year he died, and his son Sïang went away and dwelt in Shang-k'iu, where he was supported by the prince of P'ei. That is the court annalist's way of stating that the new emperor fled to a distant city, leaving Î in possession of the capital. Î's usurpation is recorded by Tso and is the consistent Chinese tradition. Seventy years were destined to elapse before the imperial family recovered the capital. It seems then that the proclamation against Hsî and Ho was followed by a brief war of two years, which ended in the victory not of the emperor, but of the usurper, and I suspect that the astronomers who had been singled out for attack, would have their share in the triumph.

*Eclipse of Odysseus.*

The next oldest eclipse to which I would refer is the disputed eclipse in Homer's *Odyssey* on the day of the slaughter of the suitors. We are prepared for it in two passages where the unrecognized Odysseus predicts his own return first to the swineherd Eumaeus and afterwards to Penelope. I use Professor A. T. Murray's translation, except that I render λυκάβας literally 'journey of light', instead of, with Professor Murray, 'day'. The new moon was on the fourth day after the evening when Odysseus spoke to Eumaeus, the day after the evening when he addressed Penelope. The first passage (ξ 158–64) runs :—

'Now be my witness Zeus, above all Gods, and this hospitable board, and the hearth of noble Odysseus to which I am come, that verily all these things shall be brought to pass even as I tell thee. In the course of this self-same journey of the light Odysseus shall come hither, as the old moon wanes, and the new appears.

He shall return, and take vengeance on all those who here dishonour his wife and his glorious son.'

He addresses Penelope (τ 303–7) in exactly the same words, except that, not being at supper, he omits the reference to 'this hospitable board', and to fill the vacant space in the line, expands the description of Zeus to 'highest and best of gods'. Lastly, in addressing a lady he omits the prophecy of vengeance.

On the evening when Odysseus had made his prediction to the swine-herd, Homer tells us that the night was σκοτομήνιος, that is, that there was no Moon in the evening. (ξ 457.)

Again, we are twice told when the fatal day has come, that it is a feast day, the new moon festival no doubt (ν 156, 276), and then just before Penelope goes to fetch the bow, the seer Theoclymenus sees the portents of the impending doom of the suitors (ν 351–7):

'Ah, wretched men, what evil is this that you suffer? Shrouded in night are your heads and your faces and your knees beneath you; kindled is the sound of wailing, bathed in tears are your cheeks, and sprinkled with blood are the walls and the fair rafters. And full of ghosts is the porch and full the court, of ghosts that hasten down to Erebus beneath the darkness, and the Sun has perished out of heaven, and an evil mist hovers over all.'

'The Sun has perished out of heaven' ought to mean a total eclipse of the Sun, and, as we have seen, the way is prepared for it by indications of the age of the Moon, all consistent with such a phenomenon. Plutarch[1] and Eustathius take it this way. Of recent commentators Monro notes that we do not hear of any actual darkness that day, and urges that the darkness or night is that of death, to which I should reply, Why should we be told of the darkness again, and why should not an eclipse be

[1] *De Facie*, 931 F.

sent as a portent of death? Merry regards the reference to an eclipse as not impossible, but he thinks the blotting out of the Sun is merely the climax of the vision. Van Leeuwen does not even deign to notice the ancient interpretation. On the other side, Herwart von Hohenburg[1] in 1612 went so far as to date the return of Odysseus and the Trojan war by means of the eclipse. I suspect that the eclipse was in the legend as Homer received it, but I am not prepared to use it to date the Trojan war.

### *Eclipse of Babylon.*

I will pass now to another eastern eclipse. A contemporary Babylonian chronicle of portents[2] states that 'on the twenty-sixth day of the month Sivan in the seventh year the day was turned to night'. The record belongs to the eleventh century B.C., and there was an eclipse of the Sun in B.C. 1063, on July 31,[3] which may well have been at the end of Sivan, though it should be the 28th not the 26th day of the lunar month, and this eclipse was total in southern Babylonia. If the record refers to a total eclipse of the Sun, it becomes one of the foundation stones of Babylonian chronology, and Professor Langdon so regards it. Unfortunately the name of the king in whose seventh year the phenomenon occurred is lost. Professor Langdon suggests Nabu-shum-libur.

[1] *Novae, verae, et exacte ad calculum astronomicum revocatae chronologiae* (1612), 10. The eclipse on which he fixes is that of B.C. 709 July 18, and he concludes that the fall of Troy was in B.C. 712.

[2] King, *Chronicles concerning early Babylonian Kings* (1907), ii. 76.

[3] I may perhaps to avoid confusion explain that in this lecture I reckon by the system used by historians of dates before Christ, reckoned by ordinal numbers expressed as cardinals. Astronomers reckon by negative cardinals, so that their 0 is the historical B.C. 1, their −1 is the historical B.C. 2, their −1062 is the historical B.C. 1063.

*The Shih King Eclipse.*

In B. C. 776 the Shih King,[1] the Chinese Book of Poetry, records an eclipse of the Sun preceded by an eclipse of the Moon. The exact date of the solar eclipse is given and can be verified astronomically. This is the first of a large number of eclipses, by means of which Chinese chronology can be confirmed.

*Eponym Canon Eclipse.*

In B. C. 763 an Assyrian chronicle which includes the text of the eponym canon records an eclipse of the Sun.[2] The year can be established by simple enumeration from the canon of eponyms. The month is named. Both are confirmed by astronomical computation. This confirms the accuracy of that canon, and so involves a correction amounting to 44 years to the chronology which was derived from the books of Kings and Chronicles by Archbishop Ussher.

This eclipse is the first historical eclipse contained in Ginzel's *Spezieller Kanon*, a valuable work largely used by students of history and doubtless familiar to many of my audience. In regard to this book I may say that, although the elements of the motion of the Moon as used by Ginzel are glaringly inconsistent both with gravitational theory and with modern observations, they have been made to fit the ancient eclipses of the Sun, and the zones marked on his maps are sufficiently reliable in all but the most delicate cases.

*Lunar Eclipses of the Almagest.*

In B. C. 721 occurred the first of the lunar eclipses recorded by Ptolemy in his Almagest. The earlier of these eclipses were observed and recorded in Babylon

[1] Legge, *Sacred Books of the East*, iii. 355-7.
[2] Sayce, *Records of the Past*, new series, ii (1890), 124.

and were used in combination with later eclipses by Hipparchus about six centuries later and by Ptolemy between two and three centuries after Hipparchus to determine the different elements in the motion of the Moon. It is probable that they had previously been used for a similar purpose by the Babylonians themselves. In modern times great use has been made of these eclipses for the determination of the Moon's acceleration, though I have preferred to ignore all the ancient lunar eclipses before the Greek period. These eclipses are referred to the years of Babylonian, and after the Babylonian series to years of Persian and Egyptian kings and of Roman emperors, and Ptolemy gives a canon showing the regnal years of these kings and emperors from B.C. 747 onwards. As modern eclipse computations verify this canon consistently, we have in it a reliable foundation for ancient chronology, and through the Babylonian and Persian dates we are able to fix Hebrew and Greek dates. This canon has been recognized from the close of the sixteenth century as our primary chronological authority. The latter part of the Assyrian eponym canon is found to be in agreement with it, and we can therefore carry dates back through the whole range of that canon into the tenth century B.C. These dates also give us a starting-point for Babylonian chronology for which we now have lists of kings extending through thousands of years, but we have few astronomical checks on the chronology before this series of eclipses.

### *Eclipses of the Annals of Lu.*

One year later than the first of Ptolemy's eclipses falls the first of thirty-six eclipses recorded in the Annals of the Chinese state of Lu. These enable us to fix Chinese chronology with certainty for the period

covered by these annals, and there are numerous similar observations recorded down to modern times. It is found that thirty-two of the thirty-six eclipses of the Annals of Lu can be confirmed by astronomical computation.[1] The other four never happened. But the whole style of the annals is such that none but a contemporary could or would have composed them, and it seems to me the easiest explanation of the four false eclipses that a watch was kept for eclipses at every new moon and that observers sometimes imagined that a part of 'the Sun was eaten', as the phrase went, when the phenomenon was not really astronomical at all. If an astronomer was liable to be executed for failing to observe an eclipse, he would probably take no risks, and would record anything that the civil authorities might be likely to regard as an eclipse.

### *Eclipse of Archilochus.*

Selecting only the eclipses which have excited some unusual interest, I come next to the eclipse of Archilochus, who wrote:[2]

'Nothing there is beyond hope, nothing that can be sworn impossible, nothing wonderful, since Zeus father of the Olympians made night from midday, hiding the light of the shining sun, and sore fear came upon men.'

This eclipse must have been that of B. C. 648 April 6, the earliest fixed date in Greek history. Archilochus is known to have divided his life between Paros and Thasos. According to my solution, the eclipse was

[1] Three of these, B.C. 709 July 17, B.C. 601 September 20, and B.C. 549 June 19, are described as total. Introducing my elements as corrections into Schram's tables, I find that the first was total in the capital and the last in the state of Lu. The eclipse of B.C. 601 was total in the extreme south of the Chinese empire of that time. At K'euh Fow it attained a magnitude of 10·7 digits.

[2] Fr. 74 in Bergk, *Poetae Elegiaci et Iambographi* (1915).

total at Thasos, but not at Paros. So we may assume that Archilochus was at Thasos in B.C. 648.[1]

*Eclipse of Thales.*

I come now to the most famous eclipse of antiquity, the eclipse predicted by Thales of Miletus. The narrative in Herodotus[2]—I use Dr. Godley's translation—runs as follows:

'There was war between the Lydians and the Medes for five years; each won many victories over the other, and once they fought a battle by night. They were still warring with equal success, when it chanced, at an encounter which happened in the sixth year, that during the battle the day was turned to night. Thales of Miletus had foretold this loss of daylight to the Ionians, fixing it within the year in which the change did indeed happen. So when the Lydians and Medes saw the day turned to night they ceased from fighting, and both were the more zealous to make peace. Those who reconciled them were Syennesis the Cilician and Labynetus the Babylonian.'

Labynetus is of course Nebuchadrezzar, whose army had destroyed Jerusalem in the preceding year.

[1] Professor Beloch, *Griechische Geschichte*, i. 2 (1913), 351, shows that it appears from Aristotle, *Rhet.* iii. 17, 1418 b 28, that the passage cited referred to Neobule, and from Dioscorides, *Anth. Pal.* vii. 351, that Neobule lived in Paros, which creates a slight presumption that the eclipse was observed at Paros. To make it total at Paros without undue violence to other elements in the motions of the Sun or Moon, I should suggest increasing the Moon's acceleration found by me from 10·8″ to 11·4″ per century and the Sun's from 1·5″ to 1·8″. This would slightly improve the agreement with results deduced from elements other than eclipses of the Sun, but would reduce the magnitude of the eclipse of Plutarch at Chaeroneia, in which many stars are said to have been seen in all parts of the heavens, to 11·92, where totality is 12. The Sun was 48° above the horizon at the time of the eclipse of Plutarch, and in the absence of evidence that any but the very brightest planets could be seen with the Sun at such an altitude unless the eclipse was total, I hesitate to make the correction, and adhere to my solution, which makes the eclipse of Archilochus total at Thasos, but not at Paros. Of course if the reference to a total eclipse and, as it would seem, to the corona in Plutarch, *De Facie*, 932 B, is intended to apply to the individual eclipse described in 931 D, E, this diminution in the magnitude of that eclipse will not be permissible.

[2] i. 74.

The record in Herodotus clearly refers to a total eclipse of the Sun, and there is no doubt that it was the eclipse of B. C. 585 May 28. That year or years in the immediate neighbourhood are given by those Greek and Latin writers who have inherited the chronological tradition. I have discussed the method by which Thales predicted the eclipse in a paper on Cleostratus in the *Journal of Hellenic Studies* for 1919.[1] It will be sufficient on this occasion to say that Thales must have used the Babylonian cycle of eighteen years and have based his prediction on the eclipse of B. C. 603.

On the accompanying map the northern and southern limits of the zone of totality are marked by straight lines. The zone includes the northern part of Ionia and the whole of Lydia. Astronomers, misled by historical students, have generally assumed that the fighting would be near the river Halys, across which Croesus advanced against Cyrus forty years later, and have attempted to amend the lunar theory accordingly. It will be seen that the position of the zone of totality indicates a battle-field in southern Asia Minor rather than in the neighbourhood of the Halys. Sir William Mitchell Ramsay has contributed a most interesting article to the *Journal of Hellenic Studies* for 1920,[2] in which he draws attention to the military importance of the Pisidian road, which is indicated on the map by a curved line passing south of Iconium. This road is one of the few routes in Asia Minor which command a sufficient supply of water to satisfy the needs of an army. If the fighting was in the neighbourhood of this road, it was close to the Cilician frontier, and this may have been the reason why the Cilician ruler should have been selected as one of the mediators. He would be the nearest neutral sovereign available.

[1] xxxix. 180–3. [2] xl. 89–112.

*Eclipse of Sardis.*

I pass over the total eclipse of the Sun which is said by Herodotus[1] to have been seen when the army of Xerxes had left Sardis. All that I wish to say about it is that, like four of the Chinese eclipses, it didn't happen.

*Eclipse of Thucydides.*

The next eclipse to which I would invite your attention is recorded in the second book of Thucydides[2] and took place in B.C. 431 August 3. Thucydides describes it as follows:

'During the same summer at the beginning of a lunar month (the only time, it seems, when such an occurrence is possible) the sun was eclipsed after midday; it assumed the shape of a crescent (literally "became moon-shaped") and became full again, and during the eclipse some stars became visible.'

The statement that stars were visible during this eclipse has led to interesting discussions. My elements of the motion of Sun and Moon would give the eclipse at its greatest phase a magnitude of 10·50 digits at Athens; as 12 digits constitute totality, this would mean that seven-eighths of the Sun's diameter were eclipsed. Ginzel makes it 10·03 at Athens, uncovering about a third as much again as I do. The difference is not unimportant. It is generally supposed that no star except Venus is visible except when an eclipse verges on totality, and it has therefore seemed necessary to make one of three assumptions:

(1) That the plural 'some stars' is an exaggeration. I regret that in my paper published in the *Monthly Notices of the Royal Astronomical Society* for last December I adhered to this view.

[1] vii. 37.

[2] ii. 28, tr. by Smith (1919), pp. 309, 311.

(2) That the elements either of the Moon's motion or of the Sun's need a drastic change so as to bring the zone of annular eclipse close to Athens. The magnitude, if annular, would be 11·88 or $\frac{99}{100}$ of totality. This was Dr. Cavell's solution,[1] but the elements which he adopts fail to satisfy the critical eclipse of Hipparchus.

(3) That the place of observation was at a distance from Athens. The Rector of Lincoln has ingeniously argued [2] that Thucydides may have been on an embassy to the Thracian king and have watched the eclipse from the neighbourhood of Adrianople.

Now all these suggestions are rendered unnecessary by the results established by last month's eclipse. That eclipse attained a magnitude of 10·7 digits at Oxford; that means that eight-ninths of the Sun's diameter were eclipsed. That is, one-fifth of a digit more than at Athens in B. C. 431. In neither case was the Sun high above the horizon. At Oxford last month the eclipse attained its greatest phase at 9.47 a.m. summer time, that is, at 8.40 a.m. local solar time, while at Athens in B. C. 431 the greatest phase according to my computation was at 5.31 p.m. local solar time, ours being a morning eclipse, theirs an evening eclipse. I find that the Sun's altitude here was 29° above the horizon, the Sun's altitude there was 17°. The sky was remarkably clear here, with occasional thin clouds. The sky is nearly always clear at Athens. At our eclipse the brightest stars in the sky were Venus and Vega. At Thucydides' eclipse the brightest stars in the sky were Venus and Vega. Probably the Athenian eclipse would be the better for seeing stars, the difference of 12° in the Sun's altitude being more important than the difference of a fifth of a digit in the

[1] First made in *Monthly Notices of the Royal Astronomical Society*, 65 (1905), pp. 861–7.
[2] *Classical Quarterly*, xiii (1919), 127, 128.

magnitude of the eclipse. At Oxford nearly all people with normal eyesight, among whom, alas, I cannot number myself, saw Venus without optical aid. I know of two[1] who saw Vega without looking for it and without knowing where it was to be found, and of two others[2] who thought they saw it, but could not be sure. I know of two who saw Mercury, one of whom[3] caught only a momentary glimpse, while the other[4] kept it in view for twelve minutes. I should be glad to hear from any one who saw one or more stars besides Venus. At Cambridge, where the magnitude was approximately the same as at Oxford, four observers are stated to have seen Vega and one Mercury.[5] I have not heard of stars other than Venus being seen with the naked eye where the eclipse was of less than 10·6 digits magnitude. Now, if we in Oxford could see stars in the plural, why could not the Athenians in similar circumstances? Our naked-eye observers have therefore achieved three results: (1) they have rendered it unnecessary to pull about the motion of Sun or Moon to satisfy this eclipse; (2) they have established the veracity of Thucydides, and (3) they have deprived him of an excuse for a delightful trip to Adrianople. I fear, however, that

[1] Mr. P. V. M. Benecke of Magdalen College and Mr. L. G. Wickham Legg of New College.

[2] Mr. J. A. R. Munro, Rector of Lincoln College, and Mr. W. A. Fotheringham of Magdalen College.

[3] Mr. Barrett of the Radcliffe Observatory.

[4] Mr. W. A. Fotheringham.

[5] *The Observatory*, xliv (1921), 144. In the *Journal of the British Astronomical Association*, xxxi (1921), pp. 267, 268, 276, 277, it is reported that at Quoybelloch, Deerness, Orkney, some pupils of Mr. Moar saw four or five stars. This would be within the zone of annularity (maximum phase 11·7 digits). The Rev. Dr. Fellowes, of The Cloisters, Windsor Castle (maximum phase 10·6 digits), reports having seen Venus, Mercury, Vega, and Capella with the naked eye. Arcturus was seen, apparently, at Hereford (maximum phase 10·8 digits), and four girls at Stonehouse (maximum phase 10·8 digits) saw Aldebaran. The observers of Arcturus and Aldebaran do not appear to have known where to look, and the stars were only identified by their description of the position.

they have weakened the authority of other eclipses where zones of totality have been deduced from records of the visibility of stars.

*Eclipse of Nicias.*

There is an old dispute among astrologers whether celestial phenomena cause events in this world or merely forewarn those who have the cunning to understand them. What may have been the relations of eclipses to other disasters I do not profess to say, but there can be no doubt that in the year B. C. 413 an eclipse of the Moon actually caused one of the most dramatic and appalling catastrophes recorded in human history. The Athenian fleet and army were engaged in the siege of Syracuse, both under the command of Nicias; the fleet lay in the great harbour, the army had attempted to blockade the city on the land side. The Syracusans had, however, succeeded in preventing circumvallation by carrying a wall of their own across the proposed Athenian line. Demosthenes had just arrived with large reinforcements to the Athenians; he had failed in an attempt to capture the enemy's cross wall and he had concluded that the reduction of Syracuse had become impossible, and urged immediate retreat. Nicias delayed, and meanwhile the Syracusans were reinforced and prepared for a general attack. The Athenians now determined to embark their whole force and sail away by night. The night of the full moon, August 27, was selected, and it was expected that the enemy would not discover the movement in time to resist. All preparations were ready, but the signal had not been given, when the Moon was eclipsed. The eclipse happened to be total, but I imagine that the Athenian soldiers and sailors did not wait for the total phase. They clamoured against

departure. Nicias consulted the soothsayers, who bade him stay thrice nine days, a complete round of the Moon, and he refused to discuss the question of departure till those days should be over. Long before those twenty-seven days expired, the Athenian expedition was no more. Defeated in the harbour, they had attempted to retreat by land, their different divisions had been surrounded, and the survivors had passed into private or public captivity. Nicias and Demosthenes had been executed, and the proudest armament that had ever sailed from the Piraeus had perished utterly, leaving Athens to struggle hard for her existence against her enemies.[1]

*Eclipse of Agathocles.*

My next eclipse may be less familiar to an Oxford audience, since it lies outside the 'Greats' period of Greek history. In August B.C. 310 Syracuse was being blockaded by sea and was threatened with a siege by land, but this time the enemy was not Athens, but an older naval power, Carthage. Agathocles, the tyrant of Syracuse, slipped out of the harbour with sixty ships on the 14th of August. He was pursued by the blockading fleet, who, however, abandoned the chase after nightfall. On the following morning he and his fleet saw a total eclipse of the Sun.[2] According to my computation the middle of the eclipse was about 7.37 local solar time. He proceeded on his way and landed at Latomiae near Cape Bon on the African coast after a voyage of six days and six nights. It has long been a disputed point whether Agathocles sailed north or south of Sicily. It will be seen from the map, where the parallel lines indicate the limits of totality, that there is no astronomical difficulty

[1] Thucydides, vii. 50. See the comments in Plutarch, *Nicias* 23.
[2] Diodorus, xx. 5.

in the way of a supposition that he sailed north of Sicily. If he sailed south, we should expect him to be still to the south of the zone of totality when the eclipse was seen next morning. But I cannot say that the southern route was impossible. If he kept in close to land, a voyage of seventy-five miles or thereabouts would bring him to the southern edge of the belt of totality. And who shall say for certain that he did not make seventy-five miles by the morning after he set sail? It must be remembered that on the first day he had to run for his life. On the other hand, the speed of a fleet is that of its slowest ships, and, whatever might be done by individual ships, seventy-five miles is a liberal estimate for a fleet of sixty ships in a voyage of part of a day and the following night. The whole voyage, which occupied six days and six nights, is only 270 miles. Moreover, he probably did not keep close to land, since he purposely kept both his own men and his enemy ignorant of his destination, and the further he went from the land, the further he would have to go before coming within the zone of total eclipse as I have drawn it. I infer, therefore, that he probably sailed to the north, but I admit that the conclusion falls short of certainty. Ginzel has deliberately adopted values for the astronomical terms so as to satisfy both assumptions as to the route traversed. This seems to me to be an attempt to gain more for astronomy from history than the evidence warrants.

### *Eclipse of Pydna.*

The last ancient eclipse to which I will draw your attention is the total eclipse of the Moon which happened in B.C. 168 June 21. Like most of those recorded in Greek and Roman history, it is connected with military operations, and the more distant the authors who

described it were from the event, the more detailed is the knowledge which they show. This eclipse found Rome at war with Macedonia. Polybius,[1] cited by Suidas, tells us that 'the moon being eclipsed in the reign of Perseus the Macedonian, the saying prevailed among the multitude that it betokened an eclipse of a king. And this made the Romans more courageous, and humbled the Macedonians in their minds. So true is the proverb that there are many vain things in war'. This suggests that the eclipse happened long enough before the decisive conflict for a common rumour as to its meaning to reach both camps. Polybius was only a contemporary and he may be imperfectly reported. Anyhow his story is not particularly striking.

Cicero[2] is fuller. He tells us that Sulpicius Gallus was a very dear friend of the consul Aemilius Paulus, to whom he was serving as legatus the year before he was elected consul. That fixes the year B.C. 168. While the Romans were in camp, he says, their army was perturbed by a religious fear, because on a fine night the full moon which was shining bright was suddenly eclipsed. Then Gallus did not hesitate to proclaim publicly in the camp next day that it was no prodigy and that it had happened then and would always happen at fixed times, when the Sun was so placed as not to be able to touch the Moon with his light.

This narrative is not in full agreement with Polybius inasmuch as it suggests that the Romans were persuaded that the phenomenon was not a portent, while Polybius makes them regard it as a portent favourable to themselves. Observe that there is no suggestion that Gallus had computed the eclipse; he merely explained it by the common cause of all lunar eclipses, and his explanation was not given till the day after the

[1] xxix. 16. [2] *De Republica*, i. 15. 23.

event. Cicero indeed tells us elsewhere[1] that Gallus in his old age used to predict eclipses, a work which, no doubt, involved study and leisure. He would certainly have told us that Gallus had predicted this particular eclipse, if he had heard of the prediction. It will also be observed that Cicero does not connect the eclipse with any particular battle.

Livy[2] is the first to give us the sensational story that appears still in our standard works on Roman history. Describing the day before the battle of Pydna, he tells us that it was after the end of the solstice. The actual solstice was on June 26, but the Romans reckoned it as lasting three days. His language therefore suggests a later date—I cannot say how much later—than that of the eclipse of June 21. He also tells us that after the Roman camp had been fortified for the night C. Sulpicius Gallus, military tribune of the second legion, who had been praetor the previous year, summoned the soldiers to a meeting with the consul's permission, where he predicted to them that in the coming night the Moon would be eclipsed from the second to the fourth hour, and that this was to be no more regarded as a portent than was the monthly waning of the Moon. When the eclipse took place at the predicted time, the Roman soldiers regarded his knowledge as almost divine, while the Macedonians regarded it as a prodigy announcing the fall of their king and the destruction of their race, and spent the night in shouting and howling until the eclipse was ended. On the next day, the 4th of September of the Roman calendar, so Livy tells us, the two armies fought the battle of Pydna.

I will not trouble you with later ancient writers.

Modern scholars have almost without exception accepted Livy's romantic story in spite of its disagree-

[1] *De Senectute*, 14. 49.

[2] xliv. 36, 37.

ment with Polybius and Cicero, and in spite of its inconsistency with Livy's own statement that the battle was after the end of the solstice.[1] They have also seized upon the dates in Livy as evidence of the error in the Roman calendar, and that calendar has been reconstructed on the assumption that September 3 of the calendar of that time was identical with June 21 of the Julian calendar which we use for astronomical dates. I fear that this reconstruction must share the fate of the story on which it is based.

I am sorry to end my survey of historical eclipses by rejecting so romantic a story. But it is not all loss. Injury has been done both to astronomy and to history by a too eager enthusiasm on the part of votaries of either science to obtain exact and reliable data from the other, and the unsatisfactory character of the results thus obtained has given rise among some students of each science to an excessive scepticism of results obtained from the other. Our true path is the *via media*. We must weigh our evidence with caution. Most of the results achieved are of solid value and where they can be confirmed by other evidence they are of great weight. Each science has need of the other, but neither has a right to force from the other more than it is able to give.

*Supplementary Note.*

Since the note on p. 26 was written I have learned from Dr. Fellowes that he had carefully determined in advance the places where stars might be expected. He found Vega with field glasses, but the other stars were picked up with the naked eye. In *The Journal of the British Astronomical Association*, xxxi (1921), 308, 309, Mr. H. J. Pleydell, of the Caterham Valley Council School (maximum phase 10·54 digits) reports the observation of Venus and two other stars which he unhesitatingly identifies as Vega and Altair. He states that he had difficulty in pointing them out to other observers. This is the smallest phase at which any star other than Venus was reported.

[1] Unger is an honourable exception. See his paper 'Die römischen Quellen des Livius in der vierten und fünften Dekade', *Philologus*, Suppl.-Bd. iii (1878), 201–6.

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